Remarks/Arguments

Claims 1-23 remain in the application. Claims 1-3, and 8 have been cancelled. Claims 4, 5, 6, 9, 19, and 21 have been amended. New claim 24 has been added.

Applicant respectfully requests that the instant amendment be entered after mailing of the Final Office Action. The proposed amendments do not introduce any additional limitations that have not previously been claimed. Accordingly, the proposed amendments should not necessitate any additional search by the Examiner. In addition, as is argued below, the proposed amendments are believed to place the application into allowable form.

Telephone Interview

Applicant wishes to thank the Examiner for conducting the telephone interview of June 15, 2004. A complete and proper recordation of the substance of the telephone interview, as follows:

a) No exhibits were shown nor was any demonstration conducted.

b) Claims 1, 4-6, and 8 were discussed.

c) Discussion of the prior art was limited to i) United States Patent 5,160,991 in the name of Delacourt et al., and ii) H.C. Liu, Semiconductor and Semimetals, Vol. 62, pg. 129-196, 1999.

d) The principle proposed amendments of a substantive nature involved the inclusion of those claim features that are recited in claims 2, 3, and 4 into independent claim 1.

e) The Examiner maintained the rejection of claim 1 as being anticipated by Delacourt et al. Applicant argued that the teachings of Delacourt et al. are inoperative with respect to operation at other than low temperature. The Examiner also maintained the rejection of claims 4-6 under 35 USC 103 as being unpatentable over Delacourt et al. in view of Liu. Applicant argued that the proposed combination is unmotivated, and that the proposed

combination does not teach every feature of the invention as claimed at claims 4-6. Applicant further argued that at the time of the invention, one skilled in the art could not have reasonably expected to successfully produce a quantum well infrared photodetector as claimed at claims 4-6 by combining the teachings of Delacourt et al. and Liu.

g) No agreement was reached as of the end of the telephone interview.

Claim Rejections 35 USC § 102

Claims 1-3, 8, 21, and 23 are rejected under 35 U.S.C. 102(b) as being anticipated by Delacourt et al. (US Patent 5,160,991).

Claims 1-3, and 8 have been cancelled.

Claim 21 has been amended. In particular, amended claim 21 recites a step of "utilizing the quantum well infrared photodetector of claim 4, detecting infrared radiation absent cryogenic cooling." No new matter has been added in the amendment. Applicant respectfully submits that Delacourt et al. does not teach or suggest the quantum well infrared photodetector of claim 4, as discussed in more detail below, and accordingly Delacourt et al. does not anticipate amended claim 21. A step of utilizing the quantum well infrared photodetector of claim 4 would have been novel at the time of the invention, since the quantum well infrared photodetector of claim 4 was itself novel at the time of the invention. Accordingly, Applicant respectfully submits that amended claim 21 is in proper form for allowance. Favorable reconsideration is kindly requested.

Claim 23 depends from believed allowable amended claim 21 and is also believed to be allowable. Favorable reconsideration is kindly requested.

Claim Rejections 35 USC § 103

Claims 4-6, 19, and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Delacourt et al. (US Patent 5,160,991) in view of Liu (Semiconductor and Semimetals, Vol. 62, pg. 129-196, 1999).

Claim 4 has been amended. In particular, claim 4 has been rewritten in independent form, including all of the claim features recited at claims 1-3. No new matter has been added in the amendment.

Applicant respectfully traverses the rejection of claim 4 as being unpatentable under 35 U.S.C. 103(a) over Delacourt et al. in view of Liu. In particular, Applicant respectfully submits that no combination of Delacourt et al. and Liu teaches each and every feature of the instant invention in as complete detail as is recited at amended claim 4. For instance, no combination of Delacourt et al. and Liu teaches doped quantum well layers having a doping density that is selected to be **sufficiently large** for providing high absorption during **near room temperature operation**, as is claimed at amended claim 4. Applicant submits that at column 3, lines 41-45, Delacourt et al. describes a first embodiment of a detector, in which the layer 2 consists of a "rather highly doped" semiconductive material, to enable detection without the detector being saturated. Delacourt et al. does not teach or suggest near room temperature operation of the first embodiment of a detector at column 3, lines 41-45, nor does Delacourt et al. indicate with any specificity what is meant by "rather highly doped". Delacourt et al. provides additional teaching relating to the first embodiment of a detector at column 4, line 65 to column 6, line 7. Notably, Delacourt et al. still does not teach or suggest near room temperature operation of the first embodiment of a detector at column 4, line 65 to column 6, line 7, nor does Delacourt et al. indicate with any specificity what is meant by "rather highly doped".

Applicant further submits that at column 3, line 45 to column 4, line 20, and at column 4, lines 25-52, Delacourt et al. describes a second embodiment of a detector, in which the layer 2 consists of a **non-doped** semiconducting material, "namely a material **having a residual doping that is as low as can be achieved** with known technologies." The paragraph at column 4, lines 25-35, which makes reference to Fig. 2, relates to a detector that is illuminated by a control wave (see lines 28-29, specifically). This paragraph specifies compositions and thickness of the layers specifically associated with the second embodiment of a detector. At line 30, Delacourt et al. states, "**For these**

materials, E_{ga} is equal to 1611 meV and E_{gd} is equal to 1424 meV." The values 1611 meV and 1424 meV appear only in Fig. 2, which relates to a detector that is illuminated by a control wave (second embodiment of a detector). Clearly, the paragraph at column 4, lines 36-52, which refers to "**these materials**," is a continuation of the disclosure that is provided at column 4, lines 25-35, and accordingly is directed specifically to the second embodiment of a detector. It is at line 41, and nowhere else in the teachings of Delacourt et al., that the term "ambient temperature" (which is specified as 300 K at line 44 of column 4) is presented. Applicant submits firstly that Delacourt et al. mentions "ambient temperature" only in connection with the second embodiment of a detector. Clearly, the second embodiment of a detector consists of **non-doped** semiconducting material, "namely a material **having a residual doping that is as low as can be achieved** with known technologies." This does not teach or suggest doped quantum well layers having a doping density that is selected to be **sufficiently large** for providing high absorption during **near room temperature operation**, as is claimed at amended claim 4. Applicant further submits that Delacourt et al. merely states at column 4, line 40, "Furthermore, for the detector **to be capable of working at ambient temperature**, the potential barrier to be crossed for the electrons, which has a value $h \cdot \nu_1^0$, **should be greater than kT=26 meV**...." The mere fact that the second embodiment of a detector is capable of working at ambient temperature (i.e. 300 K), by virtue of the potential barrier being greater than kT=26 meV, is no teaching that the second embodiment of a detector actually **does** work at such an ambient temperature. This is because the value of the potential barrier is only one of many parameters that must be taken into consideration for operation at ambient temperature (i.e. 300 K). Applicant respectfully submits that, at the time of the invention, one of skill in the art would have been skeptical of the teaching of Delacourt et al. at column 4, lines 40-44, relating to operation at ambient temperature (i.e. 300 K). This skepticism would have been based, in part, upon the terminology employed by Delacourt et al. (i.e. **capable** of operating..., **should** be greater than kT=26 meV...., etc.), and in part upon the overwhelming number of prior art teachings, and the generally accepted wisdom, that QWIP detectors require cryogenic cooling. The Examiner is directed to the attached

Declaration, which shows that at the time of the invention it was very widely believed that cryogenic cooling was necessary for operation of QWIP detectors.

Turning now to Liu, Applicant respectfully submits that there is no teaching of doped quantum well layers having a doping density that is selected to be **sufficiently large** for providing high absorption during **near room temperature operation**, as is claimed at amended claim 4. All examples, Figures and Tables presented by Liu specify cryogenic temperatures (see Fig. 2 which specifies 77 K, page 136 "these longer wavelength QWIPs have small potential energy barriers, which require much lower than 77 K cooling for operation," Fig. 8 which specifies 77 K, Fig. 9 which specifies 77 K, etc.). Furthermore, the Examiner has cited the third paragraph on page 168, which presents an equation for well doping. Although the doping concentration is determined as a function of temperature, T, clearly Figure 22 shows the values calculated over a range of values that are understood to be cryogenic. Fig. 22 does not extend up to room temperature or even up to near room temperature values, although these values could easily have been calculated and plotted on Fig. 22. Applicant submits that only those doping values for cryogenic temperatures, which were considered to have practical or technical significance, were plotted whilst the believed "meaningless" or "useless" values corresponding to near room temperature were understandably omitted from Figure 22.

The two references, when combined, fail to teach or suggest the inventive features of amended claim 4, specifically doped quantum well layers having a doping density that is selected to be **sufficiently large** for providing high absorption during **near room temperature operation**, as is claimed at amended claim 4. Accordingly, the proposed combination fails to teach each and every feature of the instant invention as claimed at amended claim 4.

Applicant further submits that the proposed combination fails to consider the invention "as a whole." In particular, Applicant has eliminated the need for cryogenic cooling in a quantum well infrared photodetector via the provision of a specific doping density within the quantum wells. Because this insight was contrary to the understandings

and expectations of the art at the time of the invention, the structure effectuating would not have been obvious to those skilled in the art.

Applicant still further submits that Delacourt et al. actually teaches away from the proposed combination. In particular, the second embodiment of the detector disclosed by Delacourt et al. includes a layer 2 consisting of non-doped semiconducting material, namely a material having a residual doping that is as low as can be achieved with known technologies (see column 3, lines 45-49). It is only with reference to the materials of the second embodiment of the detector that Delacourt et al. even suggest (see column 4, lines 25-44) a possible capability of operating at ambient temperature (i.e. 300 K). This teaches away from the proposed combination, since Deleacourt et al. specifically teaches that in the second embodiment of the detector, the doping is as low as can be achieved with known technologies. Accordingly, it would not have been obvious to one skilled in the art to combine the teachings of Delacourt et al. and Liu to obtain the invention as claimed at amended claim 4 having a doping density that is selected to be **sufficiently large** for providing high absorption during **near room temperature operation**. Furthermore, it is an inappropriate motivation to combine to take a first reference which tells you not to do something and to take a second reference that tells you to do that same thing, and combine them. Here Delacourt et al. teaches a quantum well structure having residual doping, there is no reason disclosed in Delacourt et al. or in the other cited reference to vary the doping concentration in the embodiment of Delecourt et al. to achieve room temperature operation. In fact, based upon Delacourt's et al. teaching, any such combination of references is completely unmotivated.

Applicant still further submits that the proposed combination is improper, as there would not have been a reasonable expectation of success at the time of the invention. In particular, Delacourt et al. teaches only that the second embodiment of a detector, in order to be **capable** of working at ambient temperature (i.e. 300 K), **should** have a potential barrier greater than kT=26meV. Delacourt et al. does not teach or suggest any other condition that must also be satisfied in order for the detector to actually work at ambient temperature (i.e. 300 K). In addition, Liu provides only examples and Figures etc. relating

to operation at 77 K (cryogenic temperatures). The section at page 168 and 169 dealing with doping densities as a function of temperature does not show any values above cryogenic temperatures. As outlined in the attached Declaration, at the time of the invention the general consensus, as supported by an overwhelming amount of published literature, was that QWIP detectors require cryogenic temperatures in order to work. There is no teaching in either one of the cited references that would suggest to one skilled in the art to form quantum well layers having a doping density that is selected to be **sufficiently large** for providing high absorption during **near room temperature operation**. Furthermore, Applicant is not aware of any teaching in the prior art at the time of the invention that would have provided a basis for a reasonable expectation of success.

In addition, it has come to Applicant's attention as a result of a supplemental search conducted on June 15, 2004, that the invention, as defined in the claims of the instant application, has already been the subject of copying by others. In particular, United States Patent Application Ser. No. 10/057,381 in the name of Plante (published as US 2003/0136909) was filed on January 23, 2002, which is less than nine months after the filing date of the instant application. Prior to the filing date of the Plante application, the Applicant of the instant Application disclosed to the Applicant of the Plante application specific features of the instant invention. At that time, the Applicant of the Plante application showed considerable interest.

Based upon the foregoing arguments, and the accompanying Declaration, Applicant believes that amended claim 4 is in proper form for allowance. The impropriety of the obviousness rejection regarding amended claim 4, as discussed above, combined with the objective evidence and secondary considerations relating to skepticism of experts and copying by others, clearly shows that the subject matter claimed at amended claim 4 is inventive and therefore non-obvious. Favorable reconsideration is kindly requested.

Claim 5 has been amended in order to correct an antecedence error and to correct various typographical and clerical errors. In particular, "the doping density (Nd)" lacked antecedent basis and has been amended to read "a doping density (Nd) of the quantum well

layers." The word temperature was inadvertently omitted after the word operating in claim 5 and has now been added. The term "degrees K" has been amended to read Kelvins, as is generally accepted in the art. The symbol for Planks constant appears as a left-pointing arrow due to a problem associated with our word processing software, and has now been replaced with the correct "h bar" symbol (i.e. ħ). No new matter has been added in the amendments. Applicant submits that amended claim 5, which depends from believed allowable amended claim 4, is also in proper form for allowance. Favorable reconsideration is kindly requested.

Claim 6 has been amended in order to correct numerous antecedence problems. In particular "the well material," and "the barrier material" lacked proper antecedent basis. Claim 6 has been amended to recite, "wherein the multi-quantum well structure includes a plurality of barrier layers alternating with the doped quantum well layers." Accordingly, "the doped quantum well layer material" and "the barrier layer material" have correct antecedent basis. In order to more clearly define the invention, claim 6 has been further amended to specify that the dopant species is Si (examples of support may be found at claim 12 as originally filed, and at page 7, lines 9-11, of the specification as originally filed). Applicant respectfully submits that no new matter has been added in the amendment. Applicant further submits that amended claim 6, which depends from believed allowable amended claim 4, is also in proper form for allowance. Favorable reconsideration is kindly requested.

Claim 19 has been amended. In particular, as a result of a clerical error claim 19 was originally filed depending from claim 8, whereas in fact it was intended for claim 19 to depend from claim 18. Since all dependent claims in the application as filed depended from the claim immediately preceding it, other than claim 19, Applicant respectfully submits that it should be evident that this is an unintentional error, and no new matter is added in the amendment. Claims 19 and 20 depend indirectly from believed allowable claim 9 and are also believed to be in proper form for allowance. Favorable reconsideration is kindly requested.

Claim 7 is rejected under 35 U.S.C. 103(a) as being unpatentable over Delacourt et al. (US Patent 5,160,991) in view of Liu (Semiconductor and Semimetals, Vol. 62, pg. 129-196, 1999) as applied to claim 6 above, and further in view of Sato et al. (US 5,077,593).

Claim 7 depends indirectly from believed allowable claim 4 and is also believed to be in proper form for allowance. Favorable reconsideration is kindly requested.

Claims 9-11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Delacourt et al. (US Patent 5,160,991).

Claim 9 has been amended in order to more clearly define that subject matter which Applicant considers to be the invention. In particular, the features of claim 4 have been included in claim 9. No new matter has been added. Applicant respectfully submits that the modification of Delacourt et al. as proposed in the Office Action mailed on 04/16/2004 is not proper, as the proposed modification would change the principle of operation and render Delacourt et al. unsuitable for its intended purpose. More specifically, Delacourt et al. only suggests operation at other than low temperatures (i.e. ambient temperature such as 300 K) with respect to the second embodiment of a detector. Furthermore, Delacourt et al. clearly teaches at column 3, lines 45-49 that the layer 2 of the second embodiment of a detector consist of a non-doped semiconducting material, namely a material **having a residual doping** that is **as low as can be achieved** with known technologies. This is so that, absent a control wave, the layer 2 is transmissive to the infrared radiation of frequency ν_1, and the detector can therefore be controllably switched between a detecting mode of operation and a transmissive mode of operation. By modifying Delacourt et al. to include layer 2 with a **dopant concentration that is selected to be sufficiently large** for providing high absorption during near room temperature operation, the layer 2 would **never** be transmissive to the infrared radiation of frequency ν_1, and therefore would be unsuitable for the purpose that was intended by Delacourt et al. Accordingly, Applicant respectfully submits that the proposed modification is improper.

Furthermore, Delacourt et al. teaches away from the proposed modification. Delacourt et al. clearly recites at column 3, lines 45-49 that the layer 2 of the second embodiment of the detector consist of a non-doped semiconducting material, namely a

material having a residual doping that is as low as can be achieved with known technologies. Delacourt et al. only suggests operation at other than low temperatures (i.e. ambient temperature such as 300 K) with respect to the second embodiment of the invention. Since Delacourt et al. specifically teaches that the doping concentration is as low as can be achieved with known technologies, and therefore implicitly teaches that even lower doping concentrations would be desirable if other technologies were known, Applicant respectfully submits that one of skill in the art would not have been motivated to provide a dopant concentration that is selected to be sufficiently large for providing high absorption during near room temperature operation. Providing a dopant concentration that is selected to be sufficiently large for providing high absorption during near room temperature operation is the opposite of the teachings of Delacourt et al., which suggests the desirability of even lower doping concentrations than are currently possible using known technologies. Accordingly, Applicant respectfully submits that the proposed modification is improper.

The same arguments that were presented having regard to amended claim 4 also apply to amended claim 9 *mutatis mutandis*. Accordingly, Applicant respectfully submits that amended claim 9 is in proper form for allowance, and favorable reconsideration is kindly requested.

Claims 10-11 depend either directly or indirectly from believed allowable amended claim 9 and are also believed to be in proper form for allowance. Favorable reconsideration is kindly requested.

Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over Delacourt et al. (US Patent 5,160,991) in view of Sato et al. (US 5,077,593).

Claim 12 depends indirectly from believed allowable claim 9 and is also believed to be in proper form for allowance. Favorable reconsideration is kindly requested.

Claims 13-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Delacourt et al. (US Patent 5,160,991) in view of Sato et al. (US 5,077,593) and further in view of Liu (Semiconductor and Semimetals, Vol. 62, pg. 129-196, 1999).

Claims 13-17 depend indirectly from believed allowable amended claim 9 and are also believed to be in proper form for allowance. Favorable reconsideration is kindly requested.

Claim 18 is rejected under 35 U.S.C. 103(a) as being unpatentable over Delacourt et al. (US Patent 5,160,991) in view of Sato et al. (US 5,077,593) and Liu (Semiconductor and Semimetals, Vol. 62, pg. 129-196, 1999) as applied to claim 17 above, and further in view of Wen et al. (US 5,352,904) and Brouns (US 5,773,831).

Claim 18 depends indirectly from believed allowable amended claim 9 and is also believed to be in proper form for allowance. Favorable reconsideration is kindly requested.

Claim 22 is rejected under 35 U.S.C. 103(a) as being unpatentable over Delacourt et al. (US Patent 5,160,991) in view of Choi (US 5,384,469).

Claim 22 depends directly from believed allowable amended claim 21 and is also believed to be in proper form for allowance. Favorable reconsideration is kindly requested.

Applicant looks forward to favourable reconsideration of the present application.

Please charge any additional fees required or credit any overpayment to Deposit Account No: 50-1142.

Respectfully submitted,

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